Earth System Observations and Analysis

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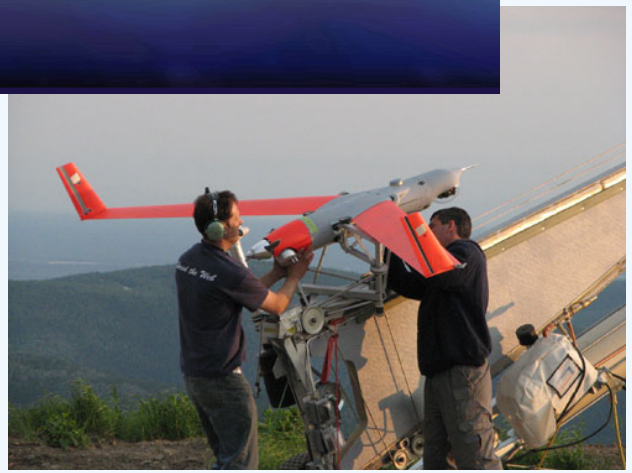
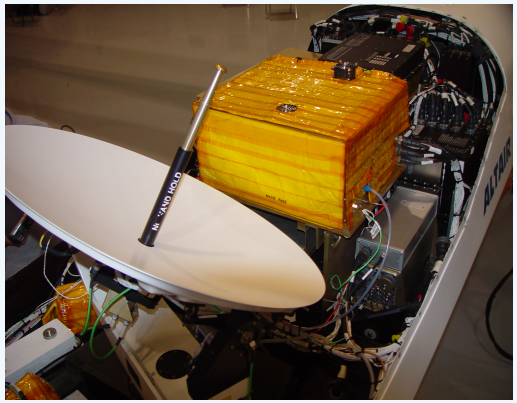
Unmanned Aircraft Systems (UAS)

What are Unmanned Aircraft Systems (UAS)?

- Powered, air vehicles with no human operator on board
- Wingspan as large as a Boeing 737 or as small as a model airplane
  - Range: 1 mile to 14,000 miles
  - Endurance: 1 hour to >30 hours
  - Altitude: 100 ft to 65,000 ft
- Launched from a runway, hand or catapulted, depending on size
- Can carry a variety of sensors



What are Unmanned Aircraft Systems (UAS)?



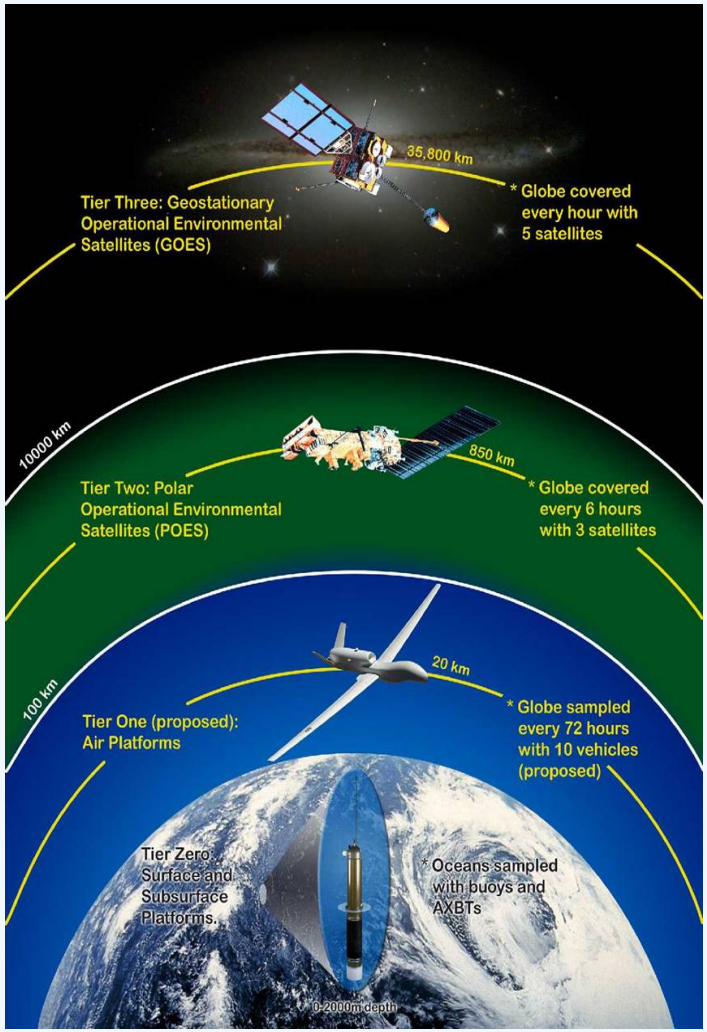
- Larger UAS equipped with Ku- band (for over the horizon flights)
- Small UAS are expendable or recoverable
- Fly autonomously (preprogrammed) or piloted remotely

Observational Gap and NOAA's Mission

Improved Observations Hold the key to saving lives and property, and conserving and protecting our natural resources.

UAS could improve Earth Systems Observations by:

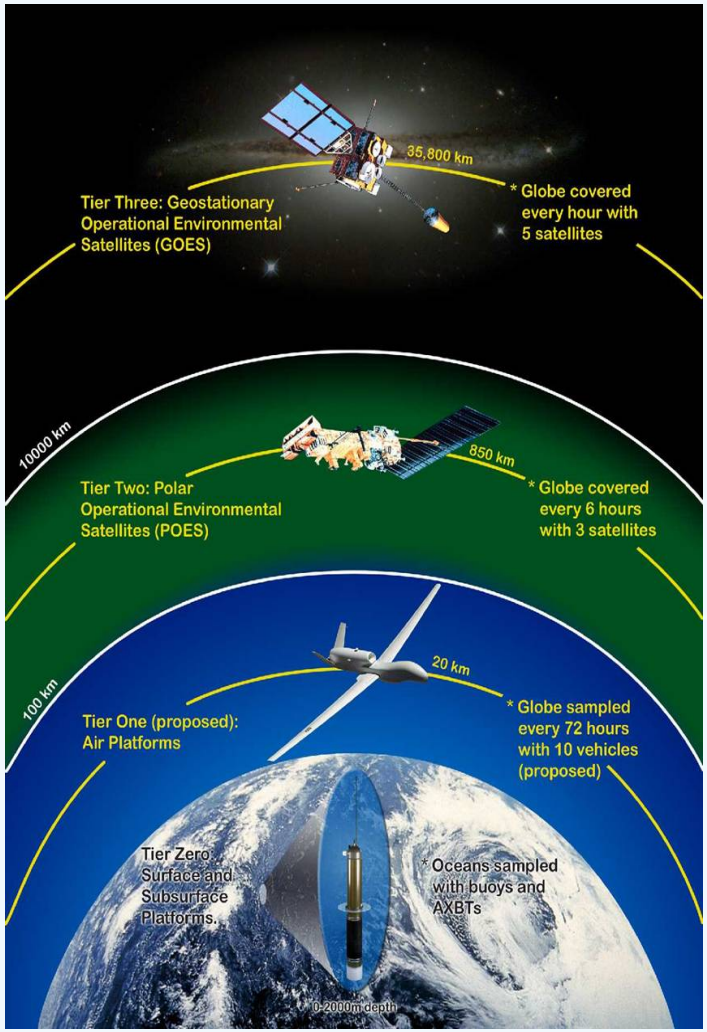
Filling the gap between satellites and surface-based sensors



Observational Gap and NOAA's Mission

- By **sampling environments** that are either impossible or impractical to observe with manned planes* i.e. "dull, dirty and dangerous:"
  - Over vast ocean expanses
  - Low-level hurricane environment
  - Polar regions, sea ice, glacier melt
  - Wild Fires
  - Fisheries Enforcement

**Technology and Mission Support Goal, 5-yr plan*

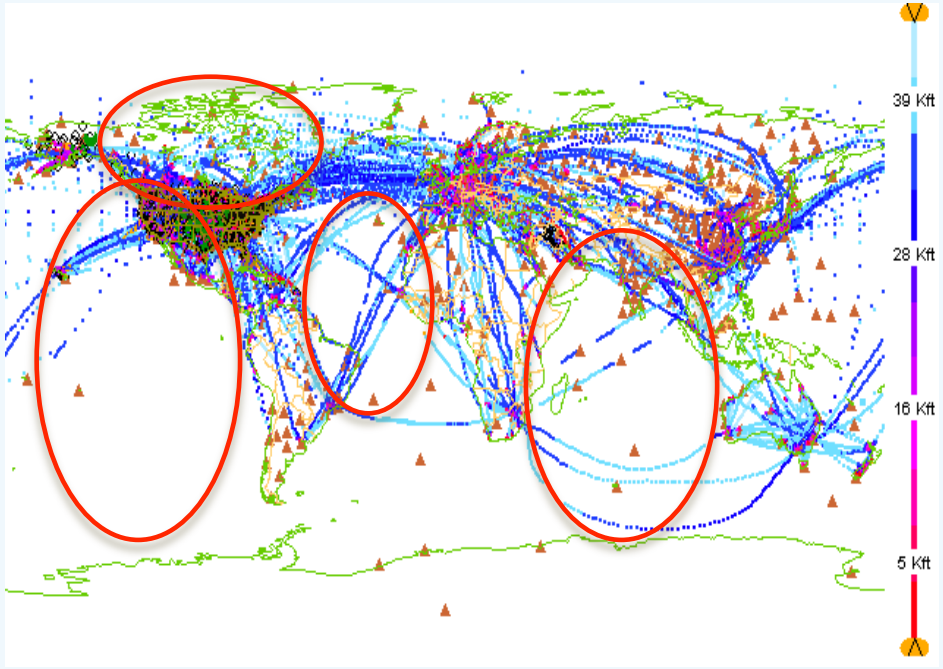


Implementation Strategy and Tests

- To demonstrate ability of UAS to collect measurements to fill observational gaps, and to provide a scientific basis for making informed decision for acquisitions.

- Three geographic testbeds were identified from which the tests were conducted over a five-year period
  - The Gulf Testbed
  - The Pacific Testbed
  - The Arctic Testbed

- In collaboration with Federal Agencies, Cooperative Institutes, Academic community and Industry



2005, Pacific Testbed, Channel Islands Operational Test with Altair

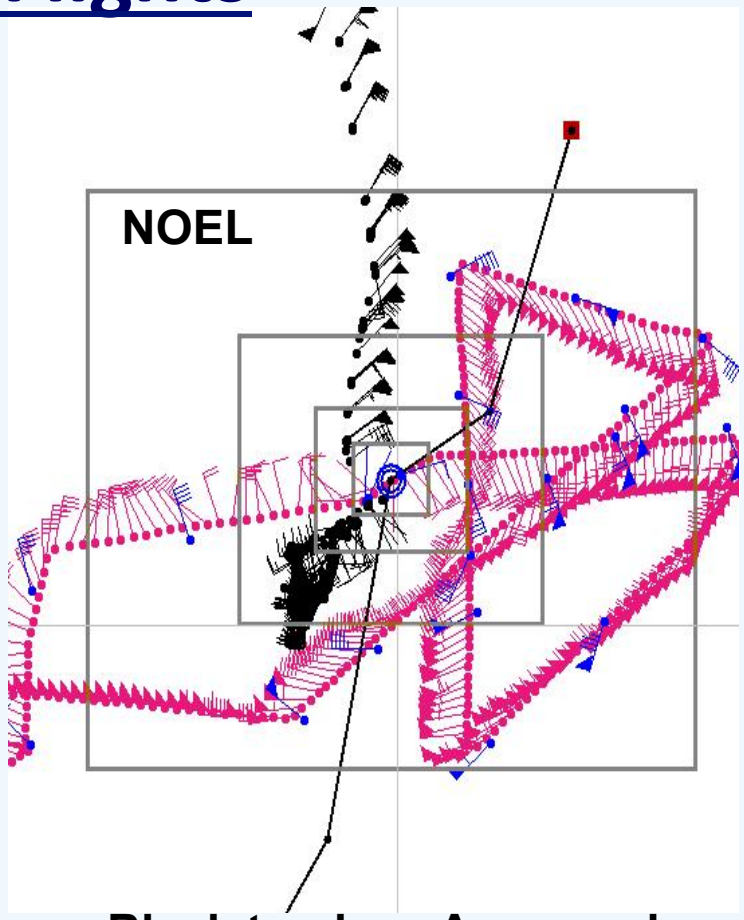
- Ocean Color Sensor – harmful algal blooms
- DCS – digital imagery for surveying National Marine Sanctuaries
- EO/IR – surveillance and enforcement of fisheries regulations
- PMVS – for measuring water vapor flux in atmospheric rivers
- GC and O3 sensors
- All instruments functioned well at 43K feet for 17 hours.

NOAA, NASA, General Atomics

U.S. DOC Bronze medal team award
for
Demonstrating the usefulness of UAS in accomplishing NOAA's mission, including operational and research goals.

Gulf Testbed: Wallops
Hurricane Low Level UAS Flights
NOAA, NASA, AAI Corp

- **GAP: low-level hurricane winds**
- **September 2005, Aerosonde (small UAS) deployed into Tropical Storm Ophelia – 55kt winds – first time an autonomous vehicle has flown into the core of a mature tropical storm.**
- **November 2007, Hurricane Noel: flew as low as 300 feet above ocean's surface for 17+ hours and sustained wind gusts up to 64 kts.**
- **Plane flew in eyewall and eye for 7.5 hours. Data was streamed to the NHC.**



Black tracks – Aerosonde
Red tracks – P3
Blue – P3 sonde drops

Arctic Testbed:
Jakobshavn Region, Greenland, July 2008
NOAA and University of Colorado

- **GAP: Knowing the volume of water stored in supraglacial lakes to better understanding the contribution of glacial runoff to sea level rise.**

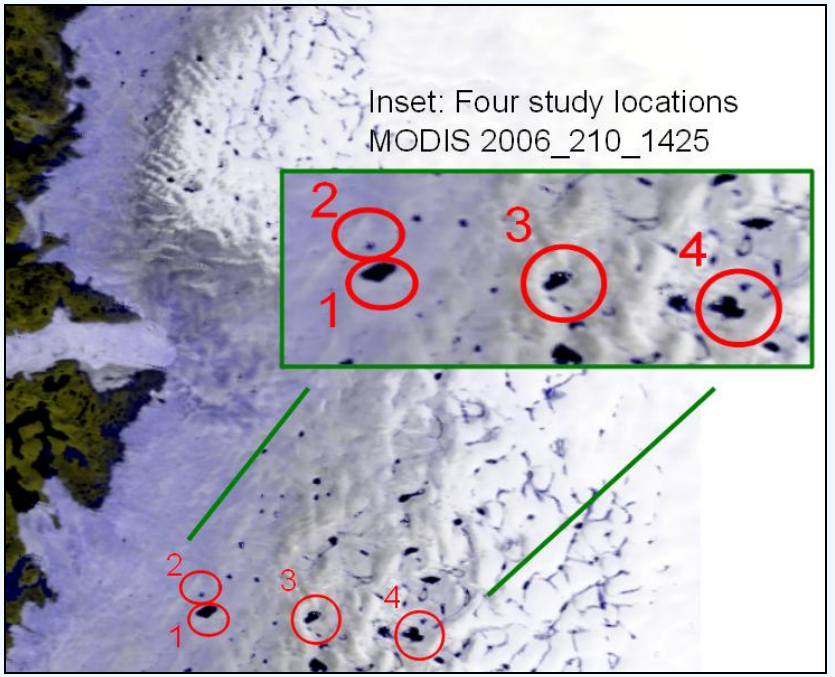
- **Scientists believe that pooling water in supraglacial lakes could conceivably reach bedrock and lubricate glacial base causing ice to break off.**

- **Sea level rise estimated at 0.06 to .37 mm/ yr. 20% of the calculated runoff is currently estimated to be retained in supraglacial lakes.**

Tied to NOAA's climate mission: *"to understand climate variability and change,"*

Arctic Testbed:
Jakobshavn Region, Greenland, July 2008
NOAA and University of Colorado

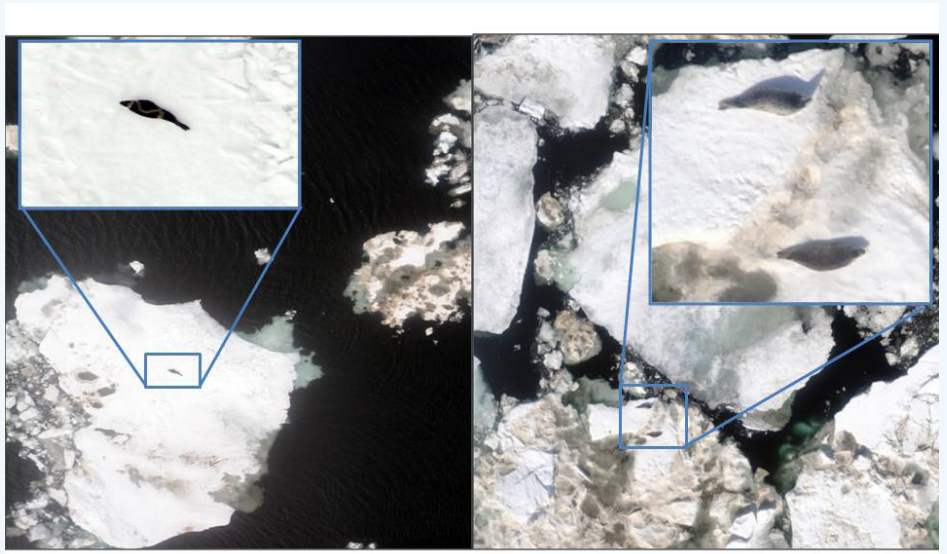
- Limited direct measurements of supraglacial lake volumes, need to develop operational methods
- UAS mapped drained supraglacial Lake #1 via lidar and calculated volume (0.043km^3)
- UAS over flew Lake #3 with hyperspectral camera for alternative depth determination
- No one has calculated the volume of water stored in the lakes. No pilots currently flying over glacial ponds. This is operationally suited to a small UAS.



Arctic Testbed:
Bering Sea, Spring 2009, Arctic Seals
NOAA, UAF, InSitu (Scan Eagle)

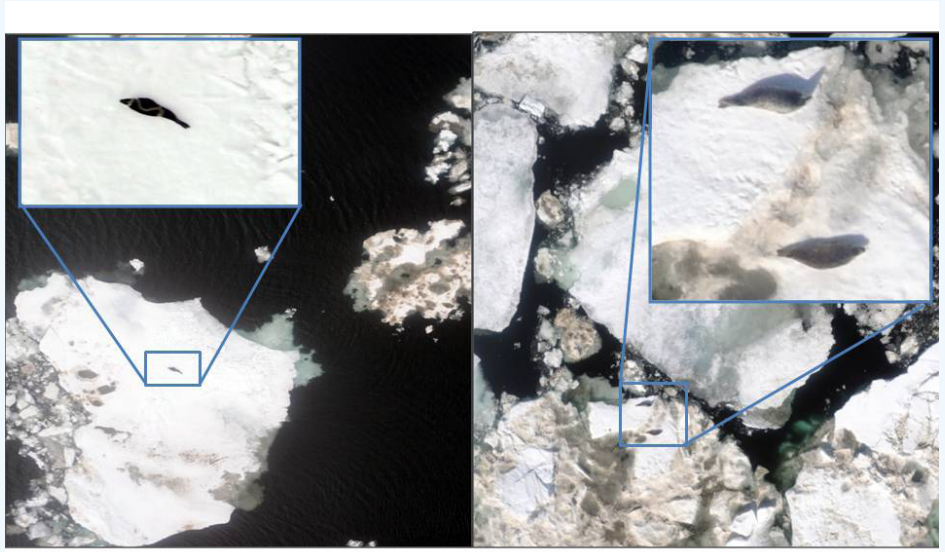
- **GAP: The abundances and distribution of ice seals in accordance with stewardship mandates under the Marine Mammal Protection Act.**

- **NOAA's Marine Mammal Laboratory's Polar Ecosystem Program tested UAS in the Bering Sea for their effectiveness for surveying sub- Arctic pack ice for ice seals**



Arctic Testbed:
Bering Sea, Spring 2009, Arctic Seals
NOAA, UAF, InSitu (Scan Eagle)

- Launched/recovered from NOAA vessel McArthur
- Digital camera in belly module of UAS, and a fixed video camera
- The images have the necessary resolution to distinguish different species and ages of ice seals - without putting a pilot at risk



Pacific Testbed
NOAA, Scripps (Cooperative Institute), ACR

GAP: Understanding the contribution of evaporation to the atmospheric river water budget, to evaluate climate models and improve the 3-5 day precipitation and flood forecasts of winter Pacific Landfall storms along the West Coast.

- **In support of the current NOAA Annual Guidance Memorandum: specifically addressing the core competency area of improving high-impact weather and water forecasts.**
- **Base of operations: Vandenberg AFB, in cooperation with Scripps Institution of Oceanography**
- **Instruments were tested on Scripps' Mantas to demonstrate flux measurement capability using small UAS to better understand the characteristics of, and moisture within, atmospheric rivers.**

Manta

Pacific Testbed:
Ghost Nets"Malolo", Spring 2008
NOAA's Marine Fisheries and Sanctuaries, Airborne Technologies

- **GAP: routine monitoring and recovery of marine debris within the Papahānaumokuākea Marine National Monument, supporting NOAA'S Mission Requirement to protect marine ecosystems**

- **Potential to provide an onsite remote aerial perspective to aid vessels tasked with the recovery of derelict fishing gear and other marine debris targeted for open-ocean recovery or attachment of satellite-tracked marker beacons.**

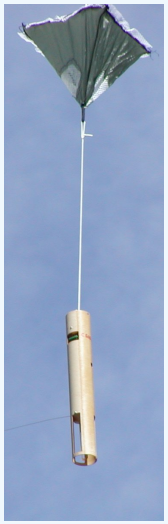
- **Malolo launched and recovered from OSCAR ELTON SETTE, March 25 – April 9, 2008**
  - **Found and tagged 2 pieces of debris**
  - **Proposed future missions include surveys of endangered species at remote islands and atolls in the Pacific**

Observing System Simulation Experiments (OSSEs)

- The UAS Program supports OSSE work
- OSSEs evaluate the impact of new observing systems on operational forecasts when actual observational data is not available
- UAS OSSE helps to guide requirements for onboard instrumentation such as dropsondes on the Global Hawk
- UAS OSSE determines the optimal flight paths and sampling strategies to increase lead time and accuracy of hurricane track and intensity forecasts

<Poster>

Mist Sonde: partners: NOAA, NASA, NCAR Collaborative partnership to build and integrate and automated dropsonde system on the Global Hawk



Summary and Way Forward

- **The NOAA UAS Program has evolved over the past 6 years into a fully funded highly collaborative program that supports NOAA's mission**
- **Tests have proven that UAS technology has the potential to fill critical gaps in our current observing system.**
- **UAS are a technology that can support programs across NOAA, and can address all the priorities of NOAA strategic plans for: Weather, Climate, Ecosystems, Commerce and Transportation**

Summary and Way Forward

- **Future projects will focus on comprehensive missions vs. single demonstrations**
- **We will be developing a systems approach to UAS missions based on observing requirements.**
- **Formulation of 2010 NOAA UAS Strategic Plan; UAS Acquisitions Plan**
- **Development of Transition to Operations roadmap based on mission science**
- **The NOAA UAS Program will address an educational component in the 2010 Strategic Plan, in support of NOAA's mission to educate students in the importance of building a national workforce literate in Science, Technology, Engineering and Mathematics (STEM) disciplines.**